RESEARCH ARTICLE

Prepare foam with injection molding method in Acrylonitrile-Butadiene-Styrene (ABS) matrix using chemical foam agent

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Abstract: In this study, it is aimed to decrease the weight of the material by using polymer foam materials with lower density instead of commercial polymers which have wide usage area. For this purpose, polymer foam was produced by using an acrylonitrile butadiene styrene (ABS) matrix and an endothermic chemical foam agent using injection molding method. The foam cell morphology, shell layer thickness and mechanical properties of the final part were investigated taking into consideration the weight-changing ratios of the foam agent content (1-1,5-2-2,5-3%).

Keywords: Acrylonitrile-Butadiene-Styrene (ABS); Foam; Mechanical; Physical; Injection Molding.

1. Introduction

Cellular or expanded plastics containing at least two phases, the solid polymer matrix and the gaseous phase produced by the foam agent, are described as polymer foams [1]. Foams are also described as materials contained gas gaps surrounded by a denser matrix, generally liquid or solid [2]. Thermoplastic foams have many appealing features such as lightness, impact damping and thermal / acoustic insulating. Thus, a thermal insulating material, packaging materials, boards, upholstery, etc. They offer a enormous potential to be used in a wide range of applications, such as [3]. It is possible to foam many commercially important polymers using physical or chemical foaming agents [4]. The preparation of the polymer foams is a two-step process including mixing and molding. The foam structure is formed during the molding process [5]. The voids in the polymer together with foam formation reduce the density and provide less raw material usage. In this way, the product price is reduced and the density of the polymer (PP, PE, PVC, PS, PU, PC), which are important for commercial use, can be adjusted by methods such as injection, extrusion, rotation molding, polymer foams with different properties can produced [5, 6, 7]. According on the composition, cell morphology and physical properties, polymer foams can be classified as rigid or flexible foams. Rigid foams are widely used in applications such as building insulation, appliances, transportation, packaging, furniture and food and drink pots, whereas flexible foams are used as transportation, bedding, carpet underlay, textile, gaskets, etc. According to the size of the foam cells, polymer foams can be classified as macrocellular (>100 μm), microcellular (1–100 μm), ultramicrocellular (0,1–1 μm) and nanocellular (0,1–100 nm) [2]. The polymer matrix used define the basic composition and basic properties for the polymer foams. The processing and application properties of polymer foams depend on the physical and chemical properties of the polymer. Changes in process parameters such as melt temperature, mold temperature, amount of foam agent, screw pitch, injection rate and injection pressure affect the cell morphology and mechanical properties of polymer-based foams produced by injection molding with foam.

In this work, acrylonitrile butadiene styrene (ABS) was used as matrix. Depending on the amount of chemical foam agent (ITP) cell morphology, shell layer thickness and mechanical properties were investigated.

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2. Experimental Data and Experiments

2.1 Materials and Methods

In this study, ABS as matrix was used provided from the Toyota Boshoku Turkey. ITP as foam agent was used provided from Clariant Company. Test specimens were produced by melting at 180 °C and using injection molding at 130 °C mold temperature and 190 °C using 1%, 1,5%, 2%, 2,5% and 3% by weight of the foam agent.

Hardness test was carried out in accordance with the ASTM D2240 standard. The hardness test was applied to 3 samples of test samples at 25ºC temperature for each parameter by using Shore D scale which is preferred for thermoplastics.

Impact tests were performed to determine the amount of energy absorbed by the material during fracture and Izod unnotched impact tests were applied to the Alarge brand device in accordance with the ISO 180 standard by using 5,5 J hammer in 2 samples with dimensions of 3x12x64 mm for impact tests.

3. Results and Discussions

The mean values of the Shore D hardness test results for the three test specimens produced for each parameter are shown in Figure 1 below and the average values of the unnotched Izod impact test results for the two test specimens are shown in Figure 2.

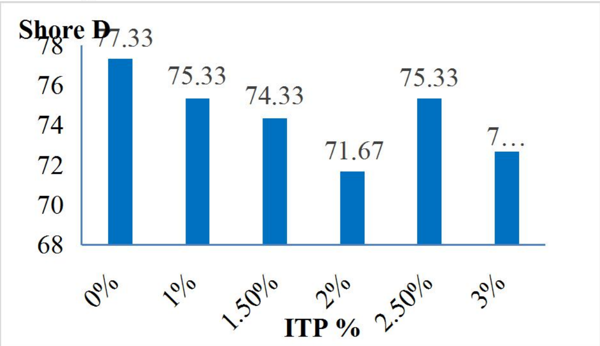

Figure 1. Hardness test results

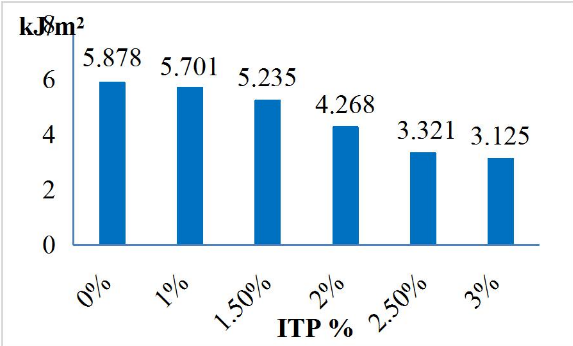

Figure 2. Impact test results

A single parameter was emphasized into consideration in the experimental studies and the effect of weight change of chemical foam agent amount on microstructure and mechanical properties was investigated. When the hardness and impact test results are examined, it is seen that these values decrease with the increase of the amount of foam agent. Because the amount of foam agent increases and the amount of foam cells increases, the shell layer thickness decreases and the hardness decreases [8]. In addition, the amount of high foam agent increases the amount of gas and more gas is obtained than is necessary. The excess amount of foaming agents causes the small bubbles to merge. Because of the large cell size distribution and irregular morphology in the foam, the irregular structure creates stress accumulation. When the bubble size decreases, the tension concentration around the bubble also decreases. Thus, the impact resistance increases [1]. However, the change in hardness and impact values in this study does not originate from the foam cells formed in the structure. Because, when the microstructure of Figure 3 is examined, foam cell formation is not observed. It is seen the spiral lamellar structure appears in the microstructure. It is believed that these changes in mechanical properties are caused by the foam agent making it brittle-spiral. The reason for not forming foam in the microstructure is presumed to be that the chemical foam agent used is not suitable for ABS matrix. Monterde *et al*. [9] performed weight reduction of 10% and 17% after injection molding of cylindrical rods of 4, 5, 8 mm in diameter and 300 mm in length using ABS matrix and N_2 physical foam agent. Forest *et al.* [10], a CO_2 foam agent was used to form foam cells on the nano-sized ABS matrix. With the selection of a suitable foam agent for the ABS matrix, work on polymer foam production can be continued.

a) b)

c) d)

Figure 3. Optical microscope image 50x a) %1 ITP fractured surface b) %1.5 ITP fractured surface ITP c) %2 ITP fractured surface d) Surface microstructure of the sample.

4. Conclusion

In this study, foamed samples with different ITP ratios were produced in the acrylonitrile butadiene styrene (ABS) matrix. Hardness values and impact strengths of the samples produced at 180 °C melting temperature, 190 °C injection temperature and 130 °C mold temperature were determined and microstructures were investigated. When the microstructure images of the samples were examined, no foam cell formation was found. However, there are some changes in mechanical properties. These changes are thought to originate from the spiral lamellar structure.

With the selection of a suitable foam agent for the ABS matrix, work on polymer foam production can be continued. In this way, materials for industrial use can be produced with advantage of low density, high strength/weight ratio.

5. Author Contributions

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6. Conflict of Interest

No conflict of interest was reported by the authors

7. Acknowledgement

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